DRAFT OUTLINE: PAPER FOR *SAN FRANCISCO ESTUARY AND WATERSHED SCIENCE*

Potential title: Making Adaptive Management Work in the California Delta
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Provisional outline

- Start with a quote from a practitioner: "There is no agreement about what adaptive management is, but everyone thinks they are doing it"

I. INTRODUCTION: WHAT IS AM?

- The problem AM is intended to address: management of large systems with complex dynamics is confronted by uncertainties in the outcomes of actions → need a structured way to learn, reduce uncertainties, and improve outcomes.
- There is a spectrum of approaches to environmental and resource management, ranging from unplanned trial-and-error to managing adaptively (involves some planning) to adaptive management (with varying degrees of structure) to formal decision-support protocols [explain each with a quick example].
- Multiple definitions of AM (including many diagrams; give refs).
- We use AM in everyday decision-making (examples) and it is used in various disciplines (e.g., engineering, business, medicine).
- Our definition: "A structured process for organized learning to address uncertainties and support flexible, science-based decision-making."
- AM involves identifying uncertainties that science can reduce, monitoring and researching to reduce uncertainties, using new knowledge to help decide next steps, gradually improving knowledge and management.
- Learning is enhanced and accelerated if alternative actions are planned and tested as experiments; this reduces the uncertainty of identifying the causes of outcomes.
- The objectives of this paper: review the features of AM, consider the impediments, and recommend innovations to help it work in the Delta.
- Genesis of this paper in the DISB review.

II. AM IN PRACTICE (a general overview)

- AM is widely touted as an effective way to manage in the face of uncertainty; it is embodied in agency protocols at many levels (USFS, etc.).
- *Why* is AM so widely embraced? (use of "best available science," sounds convincing, etc.); what are the purported benefits?

- Yet examples of its implementation as a rigorously structured, science-based decision process are few and far between [give some statistics – Lindenmayer analysis?], especially for management in large, complex ecosystems
- Examples of experiences elsewhere (avoid details; focus on what has and hasn't worked, and why).
  - other large, complex systems: Everglades, Grand Canyon, Chesapeake, Great Lakes, Puget Sound, South Bay Salt Ponds, etc.
  - other estuarine systems (see Joy's table, next page) General impediments to AM (literature)

A dozen UPDATES TO AM CASES (J. Zedler) DRAFT work in progress 5/16/2016

Note: I will be using this list of projects and AM outcomes for a peer-reviewed paper to *Estuaries and Coasts*, but not info in column 3. If we decide to use this in a ms for SFEWS, I'll need to make sure wording is not repetitive.
Note: Gulf of Mexico/BP example to be added

Estuarine case study	Outcomes of Adaptive Management (AM)	Relevance to the Delta and ISB
"The Denmark Model" demonstrates that coastal waters can be de-eutrophied; nitrogen loadings to the coast have been cut substantially (Riemann et al. 2016)	Denmark has been a leader since the 1970s--establishing monitoring of nutrient losses to coastal waters before required, beating deadlines for nitrate reduction, and becoming more efficient in nutrient use, while increasing agricultural production!	Lists changes in regulations from 1985 to present but does not discuss the interactions among key players; it's not clear what the chain of command was from identifying feedbacks to adjusting reg's. Sampling and data analysis guidelines were continuously updated, not just regulations.
Derwent Estuary, Tasmania, challenged by polluted water and altered inflows (Coughanowr and Whitehead. 2013)	This appears to be a model AM case, inspired by US National Estuary Program. A recent prize rewarded the project's reduced water pollution, improved habitat for biodiversity, improved river health monitoring, and recreation options	A 200-km^2 estuary with a large (8,900-km^2), important watershed that includes the Capitol, Hobart, and many dams that modify flows
Danube Delta on the Black Sea is highly biodiverse, but floodplains are mostly leveed; they need to be reconnected; the 19 countries don't cooperate on river restoration (Hein et al. 2016)	Several floodplains were re-connected to the river by lowering levee dams and culverts; many more projects are underway and planned. Phasing can assist learning, but it doesn't seem to be deliberate or strategic.	Europe's largest delta; potentially, ~8,102 km^2 of Danube river floodplain could be restored to improve water quality and habitat. Its exotic invaders are mussels, shrimp, clams). It has strong research support (Habersack et al. 2016)
Invasive *Spartina* removal in SF Bay; new overview in Casazza et al. (2016)	Monitoring of *Spartina* removal and endangered rail responses caused FWS and DFW to halt the eradication program and shift to native plant restoration,	Not yet clear if the invasive hybrid *Spartina* will re-establish where it was removed or whether costly removal will continue to be required (~$20M already spent).
Reducing storm surges in Dutch estuaries. The catastrophic 1953 flood convinced authorities to dam the 9-km-wide mouth of the Oosterschelde Estuary. Also, actionsin the Westeschelde evolved over time (van Buuren et al. 2010; van Staveren and Tatenhove 2016).	The Oosterschelde dam project was deferred to the 1970s, so that knowledge could accumulate with smaller dam construction projects. As a result, a new solution arose--a shorter storm surge barrier with 62 gates that could be closed during storm surges. In the Westeschelde, managers followed a rough path from international conflict in 1985, through intermediate phases, to AM in 2006.	These are old projects and they concern large bodies of open water. However, adjacent farmland is a key motivation for water control, and levee stability and undercutting along inflowing rivers are issues. Levee setbacks are being tried.
How Adaptive Management	Summarizes several legal	Endangered species issues can prompt

has fared in the courts (Fischman and Ruhl 2015)	challenges; concludes that many AM projects lack sufficient rigor—either criteria are unspecified or standards are not being met.	lawsuits, as was the case in San Diego Bay. AM of Delta endangered species could be the subject of lawsuits.
Coastal erosion and flooding in Norfolk, UK (Nicholls et al. 2015); stresses the need to involve diverse stakeholders early to develop alternative management actions.	Rising sea levels erode Norfolk beaches and cliffs. Extreme tides overtop seawalls, breach dikes and flood low-lying lands. Scientists anticipated the need for data to develop alternative scenarios and collaborated to simulate climate-change impacts.	The book promotes an innovative model that simultaneously predicts flood and erosion risks. Chapters cover early planning to implementation and outreach. Describes how coastal decision-making is subject to a host of institutional shifts.
Pierson et al. (2015) propose an expanded decision-making framework to manage Australian estuaries to adapt to climate change.	They consider 17 stakeholder/ user groups and 23 estuarine uses (their Tables 1-2). For each use, they identify climate-adaptation goals.	The result is a more comprehensive list of goals to facilitate identification of synergisms as well as trade-offs.
River restoration in France (Morandi et al. 2014)	A review of 44 projects points to uncertainties in both the ecological responses and the values (economic, aesthetic, affective and moral) attributed to responses.	Points out difficulties in evaluating the restoration; says that robust monitoring might not lead to a clear assessment of outcomes if the evaluation criteria are inadequate or inappropriate.
Thessen et al. (2016) call for integrated models for hydro-dynamics and ecological functioning; they located data from Chesapeake Bay, but data in figures and tables were difficult to locate and figures were not permanently archived	Infrastructures are needed to enable integration and synthesis of data from multiple sources to test hypotheses, track changes captured by monitoring, and allow both hindcasting and forecasting	Harding et al. (2016) say that nutrient reduction for Chesapeake Bay is weaker than for other systems subject to strenuous management, suggesting the need for more aggressive actions to counter eutrophication.
Harding, Paerl, et al. (2016) say that Chesapeake Bay mgt has not reduced nutrient inflows as much as other systems with more strenuous mgt, suggesting the need for more aggressive actions to counter eutrophication.	Monitoring data since mid-1984 show human-caused eutrophication, while historical data (back to 1945) provide a historical reference condition. Models were developed for N loadings and concentrations at the river inflow and water-quality properties in the bay proper…	Tests the hypothesis that strong climatic contrasts (irregular dry and wet periods) contribute significantly to interannual variability of water-quality properties in Chesapeake Bay.
Nillson et al. (2016) reviewed 10 long-term restoration projects in northern latitudes to determine how restoration steps are being evaluated and if adjustments are being made in response to evaluations.	Evaluation occurred throughout the three basic restoration phases (planning, implementation, and monitoring) as well as between phases	Evaluation is often not documented, making it difficult for others to learn from shortcomings; recommends using digital media to share lessons learned

III. AM IN THE DELTA

- AM is mandated in legislation, in the Delta Reform Act and the Delta Plan. Moreover, nearly all agencies have an idea that they are doing it (add other quotes?) [Does the law mandate "full-blown" AM or will projects comply if only elements of AM are invoked when they offer practical choices? Quote from the statute].
- One practitioner perception: Adaptive management "makes projects more costly, complicated, and promotes further implementation delays … less gets done, we go to more meetings, the resources continue to suffer, while the scientists wait for irrefutable answers" [comment briefly on this]
- Several factors impede implementation of AM in the Delta (give a quick example for each):
  - funding
  - risk aversion
  - limited flexibility (regulations, etc.)
  - difficulties in communication and coordination among agencies
  - inherent slowness of AM and decision-making fails to keep up with rapid changes
- Future changes will make AM more challenging, but also more necessary as uncertainties magnify: climate change, invasive species, novel ecosystems, recurrent droughts, societal and political changes, etc.
- If AM is really this difficult, is it worth it? Where and when are there benefits; what are they, for whom? [need for cost-benefit analyses].
- Take advantage of opportunities to develop and test AM:
  - capitalize on unplanned events: levee breaks, droughts, Sac Regional Sanitation, DO in Stockton Ship Channel, others?
  - use habitat restoration projects (e.g., EcoRestore) as laboratories by including designed field experiments to reveal causal linkages

IV. CHALLENGES AND APPROACHES. WHAT IS NEEDED TO MAKE AM WORK IN THE DELTA?

- Address the impediments
  - Funding: more $$, more reliably
  - Science: better use of models [via examples?] of processes and mechanisms;
  - Openness and data sharing; clear communications; focus on what is relevant and useful [examples]

    - Planning: a priori setting of decision points or targets for evaluating progress toward goals, even if they need readjustment
    - Regulation: greater flexibility in actions and permitting
    - Organizational: effective coordination, guidance, assessment → develop a unified approach to AM in the Delta
    - Nimble decision making [examples]
    - Permeable agency boundaries
    - Cultural: risk-aversion [put in positive language]
- Data management: frequent reporting of new information, interpretation, recommendations, and adoption; shared analysis/synthesis capacity
- Starting small while thinking large
    - AM as a part of EcoRestore and similar efforts
    - Building on existing coordination programs
    - The concept of a centralized coordinating body: pros and cons
- AM may not always be appropriate: AM works best when actions can be modified or changed (without great cost) and there is considerable uncertainty about outcomes.
- Elements of AM can be incorporated even if there's no overall AM plan; for example, decisions to protect an endangered species will trump actions that science might support, because the choice is in the legal arena; yet, AM can still inform resource management [add some detail about when it should not be used].
- Even if fully structured AM is not used, plans should still include a conceptual model, monitoring of what happens, analysis of the results, and communication to decision makers, all explicitly designed to address and reduce uncertainties

V. CONCLUSIONS

- The complexity of the Delta and its multiple intersections with human activities creates uncertainty at every turn, which will only grow with the accelerating changes underway. Climate change has already increased uncertainty
- AM is an effective way to manage in the face of mounting uncertainties in a complex socio-ecological system, where competing needs and agendas must be balanced, decisions are based on knowledge, and learning is captured and communicated
- Making AM work in the Delta can show how it can be done in other complex systems using a coordinated and flexible approach; it presents an opportunity to showcase the integrated, collaborative application of science to wicked problems